IJHOSCR

Review Article

International Journal of Hematology-Oncology and Stem Cell Research

# A Systematic Review of Stem Cells in Iraqi Studies

**Maeda H. Mohammad, Zaynab S. Abdulganii, Aous Kahtan Almzaien, Ahmed Majeed Al-Shammari, Ayser A. Ahmed, Hiba K. Shaker, Aseel K. Abedalsattar, Ahlam D. Armash**

Iraqi Center of Cancer and Medical Genetics Research, Mustansiriyah University, Baghdad, Iraq

**Corresponding Author:** Ahmed Majeed Al-Shammari, Iraqi Center of Cancer and Medical Genetics Research, Mustansiriyah University, Baghdad, Iraq
**E-mail:** ahmed.alshammari@iccmgr.org

Received: 10, Jun, 2024
Accepted: 11, Jun, 2025

**ABSTRACT**

Over the past three decades, stem cell therapy has undergone rapid development and has emerged as a novel treatment for many major disorders. This systematic review aims to analyze the current landscape of stem cell research publications in Iraq comprehensively. By identifying and critically evaluating existing progress, this review provides a robust overview of the field, informing the development of a well-designed national roadmap for future advancements. This analysis serves as a valuable scientific reference both within Iraq and internationally, fostering further progress in Iraqi stem cell research. Data on Iraqi stem cell publications were collected from scientific databases such as the Iraqi Academic Scientific Journals Database, Google Scholar, Scopus, PubMed, Science Direct and other search engines. These publications were classified and analyzed to evaluate their status in the field. In our systematic review, we analyzed 132 articles on Iraqi stem cell research, including 21 review articles, 9 cancer stem cell studies, and 102 methodological studies, spanning from 1977-2024. Our findings highlight a rapid increase in publications, particularly in recent years, demonstrating significant progress in stem cell research within Iraq. Key areas of focus include the therapeutic applications of stem cells, cancer stem cells, and methodological advancements, with the majority of studies utilizing human, mouse, and rat samples. This comprehensive analysis underscores the evolving landscape and the need for continued collaboration and strategic planning in Iraqi stem cell research. Our systematic review revealed a significant increase in Iraqi stem cell research publications over recent years. This growth reflects substantial progress and the critical need for continued collaboration and strategic planning to further advance the field.

**Keywords:** Cancer stem cells; Clinical trial; Iraqi studies; Stem cells; Systematic review

## INTRODUCTION

Stem cells are of interest because of their biological properties and potential medical importance in treating and repairing injured and damaged tissues. Stem cells are considered capable of proliferation, self-renewal, the production of a large number of differentiated progeny and the regeneration of tissue and can be used in regenerative and cellular therapies for many serious diseases. Currently, many biomedical approaches to regenerative medicine involve the use of stem cells[1]. Stem cells are single cells that can replicate themselves to produce the same cells or differentiate into any of the specialized cells of embryonic or adult tissues. The two main types of stem cells classified according to their developmental potency or origin can be divided into three types: totipotent, pluripotent and multipotent stem cells. Another classification of stem cells depends on their origin into embryonic stem cells, umbilical cord stem cells or adult stem cells[2].

Many Iraqi stem cell studies have been published, and a systematic review is a complex piece of research that aims to identify, select and synthesize all research published on a particular question or topic. It adheres to a strict scientific design on the basis of prespecified and reproducible methods. They provide reliable estimates of the effects of interventions. In addition to illustrating knowledge about a particular intervention, systematic reviews can also show where knowledge is lacking.

Systematic reviews use a transparent and systematic process to define a research question, search for studies, assess their quality and synthesize findings qualitatively or quantitatively. A crucial step in the systematic review process is to thoroughly define the scope of the research question. This requires an understanding of literature, including gaps and uncertainties, clarification of definitions related to the research question and an understanding of the way in which these definitions are conceptualized within literature[3].

This systematic review collected and summarized all the empirical evidence that fit pre-specified eligibility criteria and therefore answered the defined research question. Meta-analysis involves the use of statistical methods to summarize the results of these studies [4].

This review focuses on Iraqi research in the stem cell field by performing a systematic review to assess the extent of Iraqi research in this field by systematically collecting and summarizing all the published outcomes to provide useful information on the basis of published articles.

## MATERIALS AND METHODS

This study was carried out at the Experimental Therapy Department, Iraqi Center of Cancer and Medical Genetics Research (ICCMGR), Mustansiriyah University, Baghdad, Iraq. The scientific committee of ICCMGR (serial number 1 in 1/25/2021) approved this work.

### Inclusion and exclusion criteria

The process of study selection was performed by identifying relevant Iraqi publications about stem cells. The inclusion data of all the articles used in this study were selected on the basis of their titles, abstracts, methods, and results, which are relevant to the outcomes of interest. All other studies were excluded if they did not meet the eligibility criteria. Each study was eligible if it fulfilled the following eligibility criteria: (i) full text available (ii) published; (iii) conducted in Iraq by Iraqi researchers. If more than one study presented the same data, the study with more complete data was included.

### Study Selection and Data Collection

Published data on Iraqi stem cell publications were collected from scientific databases such as the Iraqi Academic Scientific Journals Database, Google Scholar, Scopus, PubMed, Science Direct and other search engines. These publications were classified and analyzed to evaluate their status in the field. Eligible studies were published between 1977 and 2024. The following data were extracted from each included study: name of the first author, year of publication, type of organism, type of study, type of sample, type of organ or tissue or cells, and type of technique.

### Statistical analysis

The study was conducted in accordance with the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews)[5]. The PRISMA checklist was used to ensure the inclusion of relevant information in the analysis (Figure 2).

Statistical analysis for systematic review was performed via IBM SPSS (International Business Machines Corporation, IBM) (Statistical Package for the Social Sciences, SPSS) Statistics Software (version 25) to determine the frequencies, percentage values, and pie charts for all the variables used in this study.

## RESULTS

One hundred forty-six (146) articles were used in this study. One hundred thirty-two (132) studies were eligible for the systematic review, which included 21 review studies, 9 cancer stem cell studies, and 102 methodology studies. In addition, 14 papers were excluded from the study (Figures 1 and 2).

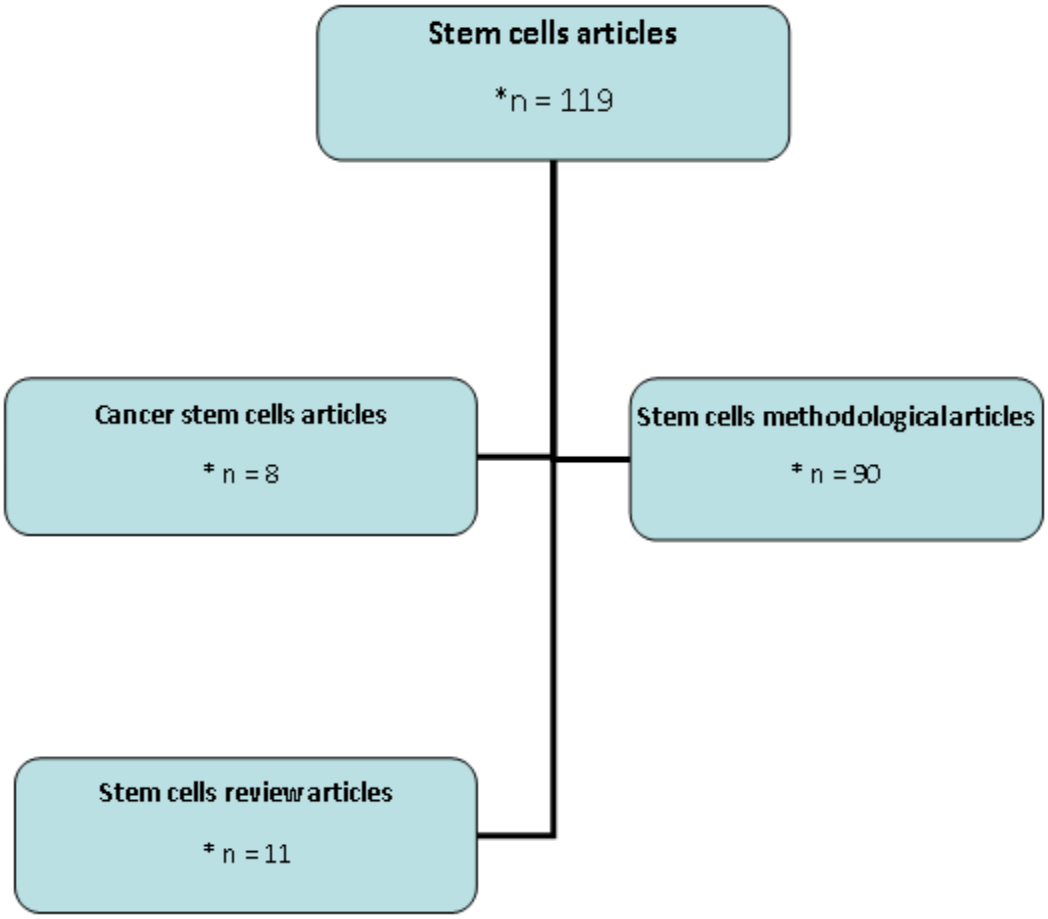


Figure 1. The division of Iraqi stem cells studies

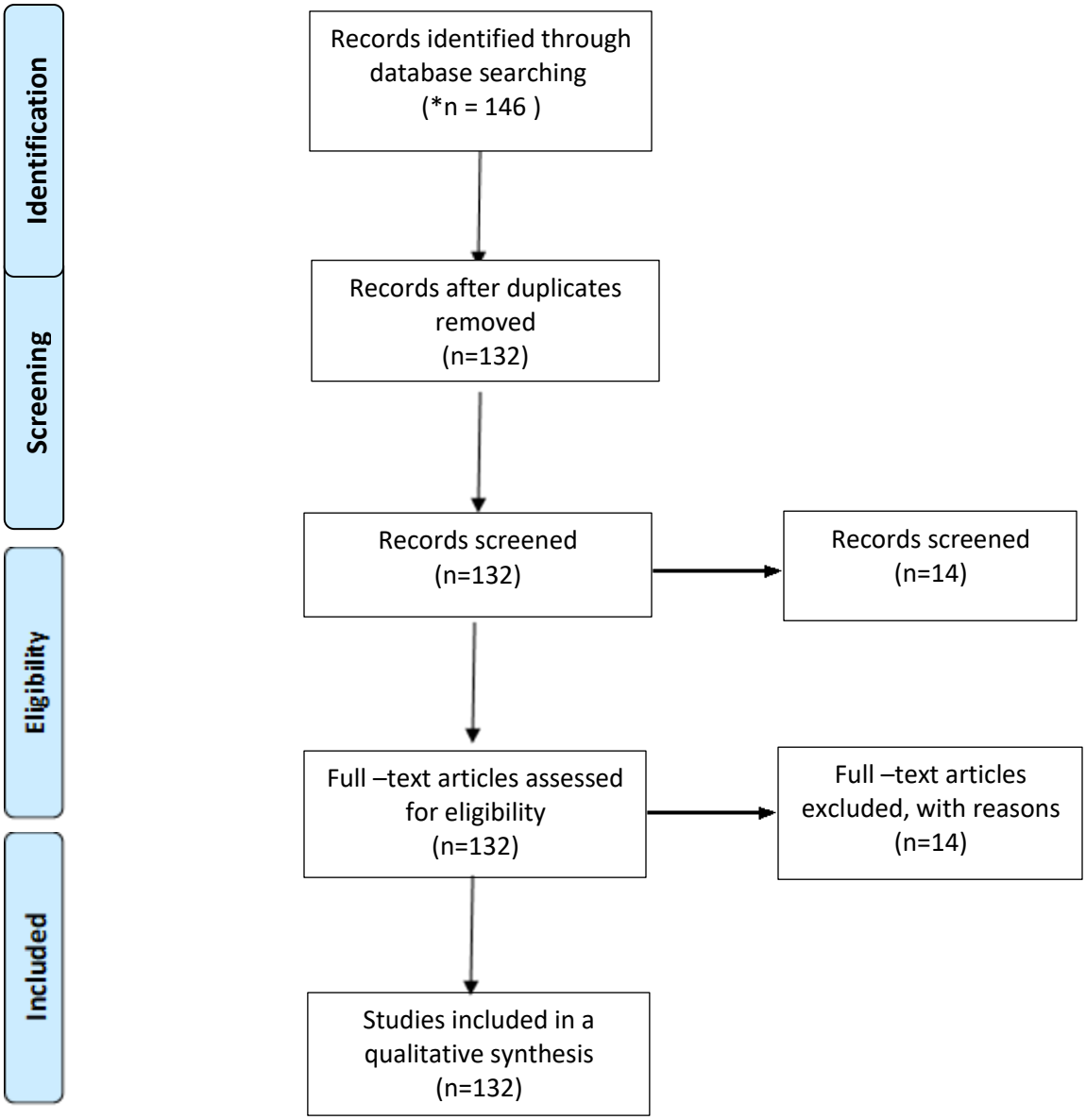


Figure 2. Flow diagram of the study selection process for the systematic review (*From:* Moher et al.)[5]
*n = number of publication articles
*n = number of articles.

**Study characteristics**

In our study, these articles showed many characteristics included in this systematic review, which covered all the stem cells included in Iraqi research, were identified. The studies included 132 studies distributed across three types of articles (as mentioned above in Figure 2). The review articles (9 studies) included the author's first name, publication year, and article links (Table 1). The cancer stem cell articles (21 studies) included the authors' first name, publication year, type of organism, type of study, type of sample, type of organ, tissue or cell, type of technique used, and article links (Table 2). The methodological studies (102 studies) included the authors' first name, publication year, type of organism, type of study, type of sample, type of organ, tissue or cell, type of technique used, and article links (Table 3).

**Table 1.** Characteristics of the review studies included in the systematic review

| | authors first name | year | link |
|---|---|---|---|
| **1** | Alauldeen Mudhsfar | 2016 | https://doi.org/10.29409/ijcmg.v9i1.177 |
| **2** | Ban J. Qasim | 2015 | https://iraqijms.net/index.php/jms/article/view/81 |
| **3** | Saba S. Alsarraj | 2014 | https://jbcd.uobaghdad.edu.iq/index.php/jbcd/article/view/523 |
| **4** | Amina N. Althwani | 2007 | https://scholar.google.com/citations?view_op=view_citation&hl=en&user=Ch_fzIAAAAAJ&cstart=200&pagesize=100&sortby=pubdate&citation_for_view=Ch_fzIAAAAAJ:dTyEYWd-f8wC |
| **5** | Waheed K. Ibrahim | 2014 | https://www.iasj.net/iasj?func=fulltext&aId=97422 |
| **6** | Khalifa E. Sharquie | 2016 | http://www.odermatol.com/2016-2-11/ |
| **7** | Araz Jaffar | 2009 | https://research.amanote.com/publication/4ZX22HMBKQvf0Bhi6EJZ/effect-of-over-dose-synthetic-estradial-17---hormone-on-some-peripheral-blood-parameters |
| **8** | Talib Fadhi Al-Zayadi | 2019 | https://muthmj.mu.edu.iq/cgi/viewcontent.cgi?article=1061&context=journal |
| **9** | Omar T. Hammoodi | 2020 | https://doi.org/10.31838/ijpr/2020.12.01.197 |
| **10** | Navid Shomali | 2020 | https://onlinelibrary.wiley.com/doi/abs/10.1002/jcp.29324 |
| **11** | Satar J. Rahi | 2020 | https://medic.upm.edu.my/upload/dokumen/2020042010381637_MJMHS_0147.pdf |
| **12** | Thekra Abdulaali Abed | 2022 | https://cdnx.uobabylon.edu.iq/research/MwBgS0vD5kOQ8AjqkIa00w.pdf |
| **13** | Ghassaq T. Alubaidi | 2022 | https://journals.lww.com/mjby/fulltext/2022/19030/stem_cells__biology,_types,_polarity,_and.2.aspx |
| **14** | E.K AL-Hamdany | 2022 | https://www.researchgate.net/publication/362311257_Identification_and_Characterization_of_Canine_Mammary_Tumors_Stem_Cells_A_Review |
| **15** | Mustafa Bakhtiar Wend | 2023 | https://search.mandumah.com/Record/1382281/Details |
| **16** | Zainab Abdelelah Abdel Kareem | 2022 | https://uomosul.edu.iq/en/regionalstudiescenter/wp-content/uploads/sites/27/2024/05/The-Position-of-Heavenly-Religions-and-Legislation-on-Stem-Cell-Therapy-Experiments.pdf |
| **17** | Mustafa Bakhtiar Wend | 2023 | https://mabdaa.edu.iq/wp-content/uploads/2023/03/3-%D8%A7%D9%84%D8%AD%D9%83%D9%85-%D8%A7%D9%84%D8%B4%D8%B1%D8%B9%D9%8A-%D9%84%D9%84%D8%B9%D9%84%D8%A7%D8%AC-%D8%A8%D8%A7%D9%84%D8%AE%D9%84%D8%A7%D9%8A%D8%A7-%D8%A7%D9%84%D8%AC%D8%B0%D8%B9%D9%8A%D8%A9.pdf |
| **18** | Ala'a Abdul-Nabi al-Medeni | 2023 | https://search.mandumah.com/Record/1407173/Details |
| **19** | Methaq Mueen Al-Kaab | 2021 | https://doi.org/10.29409/ijcmg.v14i1.322 |
| **20** | Noah A. Mahmood | 2022 | https://www.semanticscholar.org/paper/Cancer-Stem-Cell-Markers-in-Iraqi-Patients-with-Mahmood/26b789f24991289d12256f2ad3326bf21262f7d9 |
| **21** | Mohammed Siddiq Mohammed | 2021 | https://search.mandumah.com/Record/1236434 |

**Table 2**. Characteristics of human cancer stem cell studies included in the systematic review

| | Authors first name | Year | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|
| 1 | Teeba k. Hadi | 2014 | Breast cancer tissue | tissue | *IHC | https://www.semanticscholar.org/paper/Detection-of-cancer-stem-cell-in-invasive-ductal-of-Hadi-Edan/68845afb48c4eabd9a8363d8e672ca90ff396482 |
| 2 | Ahmed M. Hassan | 2017 | Renal cell carcinoma tissues | tissue | IHC | https://iraqijms.com/index.php/jms/article/view/494 |
| 3 | Zaynab S. Abdulghany | 2018 | Cancer cell lines | cell line | Molecular | https://doaj.org/article/99ea93b5db0d4ec4b210f788148aadfd |
| 4 | Ramadhan T. Othman | 2008 | Brain tumor | tissue | **ICC | https://pesquisa.bvsalud.org/gim/resource/pt/emr-86155 |
| 5 | Samar A. Alshami | 2018 | Ovarian tumor | tissue | IHC | https://iraqijms.net/index.php/jms/article/view/628 |
| 6 | Murooj J. Mohammed | 2019 | Urinary bladder cancer | tissue | IHC | http://dx.doi.org/10.22159/ajpcr.2019.v12i6.33189 |
| 7 | Hadeel I. Mohasen | 2019 | Prostate cancer | tissue | IHC | http://dx.doi.org/10.22159/ajpcr.2019.v12i6.33612 |
| 8 | Noah A. Mahmood | 2019 | Papillary Thyroid Carcinoma | tissue | IHC | https://doi.org/10.1155/2019/1659654 |
| 9 | Noorhan Sabih Al-Maliki | 2024 | Blood | ***AML | Molecular | https://doi.org/10.54133/ajms.v6i1.577 |

* Immunohistochemistry
** Immunocytochemistry
*** Acute myeloid leukemia

**Table 3**. Characteristics of the methodological studies included in the systematic review

| | Authors first name | Year | Type of organism | Type of study | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|---|---|
| 1 | Cheia Majeed | 2015 | Mouse | treatment | MSCs* | bone marrow | IHC | http://dx.doi.org/10.4236/scd.2015.54004 |
| 2 | Rafal H. Abdalla | 2016 | Mouse | differentiation | MSCs | bone marrow | ICC | https://www.researchgate.net/publication/305932980 |
| 3 | Ahmed M. Alshammari | 2012 | Mouse | isolation | NSCs** | brain | ICC | https://doi.org/10.1016/S1525-0016(16)36326-2 |
| 4 | Akram R. Jabur | 2017 | Mouse | Tissue engineering | MSCs | bone marrow | Scanning electron microscope | https://doi.org/10.1016/j.egypro.2017.07.048 |
| 5 | Baydaa A. Alqaisy | 2014 | Mouse | isolation | MSCs | bone marrow | microscopic | http://www.researchgate.net/publication/265784313 |
| 6 | Baydaa A. Alqaisy | 2014 | Mouse | isolation | MSCs | bone marrow | ICC | http://www.researchgate.net/publication/265742747 |
| 7 | Ahmed M. Alshammari | 2013 | Mouse | differentiation | MSCs | bone marrow | ICC | http://www.researchgate.net/publication/236651096 |
| 8 | Ahmed M. Alshammari | 2015 | Mouse | differentiation | MSCs | bone marrow | ICC | https://www.researchgate.net/publication/274387098 |
| 9 | Maeda H. Mohammad | 2016 | Mouse | differentiation | MSCs | bone marrow | ICC | https://www.researchgate.net/publication/282365388 |
| 10 | Maeda H. Mohammad | 2016 | Mouse | molecular study | MSCs | bone marrow | molecular | https://doi.org/10.2147/SCCAA.S94545 |
| 11 | Athraa Y. Al-Hijazi | 2013 | Mouse | isolation | Amniotic stem cells | tooth | IHC | https://jbcd.uobaghdad.edu.iq/index.php/jbcd/article/view/233 |
| 12 | Zauhair A. Jaumh | 2008 | Rat | differentiation | Hepatic oval stem cells | Hepatic tissue | ICC | https://iqjmc.uobaghdad.edu.iq/index.php/19JFacMedBaghdad36/article/view/1238 |
| 13 | Raed H. Mohammed | 2012 | Rat | isolation | MSCs | bone marrow | ICC | https://pharmacy.uokerbala.edu.iq/wp/wp-content/uploads/sites/6/2014/10/pharmacy.uokerbala.edu.iq_images_journal_3rd%20non_6.pdf |
| 14 | Majeed Arsheed Sabbah | 2011 | Human | isolation | UCBSCs*** | placenta | ICC | https://ijcmg.uomustansiriyah.edu.iq/index.php/ijcmg/article/view/58 |
| 15 | Mohamed A. Mohammad | 2013 | Rabbit | treatment | MSCs | bone marrow | ICC | https://jbcd.uobaghdad.edu.iq/index.php/jbcd/article/view/205 |
| 16 | Sarah M. Alsawalha | 2015 | Human | isolation | MSCs | bone marrow | ICC | https://ijs.uobaghdad.edu.iq/index.php/eijs/article/view/9756 |
| 17 | Oday K. Luaibi | 2015 | Dog | treatment | MSCs | bone marrow | IHC | https://www.semanticscholar.org/paper/Comparative-study-between-the-effect-of-stem-cells-Luaibi/ea11bd59c52a005e66b5e3ec4894dc3ef416f49c |
| 18 | Oday K. Luaibi | 2016 | Dog | transplantation | MSCs | bone marrow | IHC | file:///C:/Users/hp/Downloads/166-Article%20Text-215-1-10-20181205.pdf |
| 19 | Intidar M. Manati | 2009 | Human | differentiation | MSCs | bone marrow | ICC | https://jih.uobaghdad.edu.iq/index.php/j/article/view/1135 |
| 20 | Abdulmajeed A. Homadi | 2011 | Human | transplantation | HSCs**** | peripheral blood | Clinical response criteria | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3840965/ |
| 21 | Al Azawwi I.N. | 2003 | Mammalian | isolation | ESCs***** | embryo | ICC | Ph.D. Thesis, College of Science, Al-Mustansiriyah Univ |
| 22 | Ahmed H. Al Bayaty | 2010 | Horse | treatment | MSCs | bone marrow | ICC | Ph.D. Thesis, College Veterinary Medicine. University of Baghdad |
| 23 | Al Jumely B.A. | 2006 | Mouse | isolation | MSCs | bone marrow | ICC | M.S.c. Thesis, College of Science, University of Baghdad |

| | Authors first name | Year | Type of organism | Type of study | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|---|---|
| 24 | Al Kubaysi S. M. | 2012 | Ewe | treatment | HSCs | peripheral blood | ICC | https://www.researchgate.net/publication/323664190_USING_THE_HEMATOPOEITIC_STEM_CELLS_TO_TREAT_THE_IMMUNE_DEFICIENCY_IN_EWES#fullTextFileContent |
| 25 | Athraa Y. Alhijazi | 2013 | Mouse | treatment | Amniotic stem cells | tissue | IHC | https://jbcd.uobaghdad.edu.iq/index.php/jbcd/article/view/233 |
| 26 | Intidar M. Manati | 2009 | Rat | isolation | MSCs | bone marrow | ICC | https://jih.uobaghdad.edu.iq/index.php/j/article/view/1135 |
| 27 | Karim A.M. | 2013 | Rat | treatment | MSCs | bone marrow | IHC | Ph.D. Thesis, College of Science for wemen, University of Baghdad |
| 28 | Intidar M. Manati | 2007 | Rat | treatment | MSCs | bone marrow | IHC | Ph.D. Thesis, College of Education (Ibn Al-Hitham), University of Baghdad |
| 29 | Mohamed A. Mohammad | 2011 | Rabbit | treatment | MSCs | bone marrow | IHC | Ph.D. Thesis, College Dentistry, University of Baghdad, Iraq |
| 30 | Baydaa H. Mutlak | 2007 | Human | treatment | UCBSCs | placenta | IHC | Ph.D. Thesis, College of Education (Ibn Al-Hitham), University of Baghdad |
| 31 | Muthanna I. Malik | 2016 | Mouse | Genetic study | MSCs | bone marrow | microscopic | file:///C:/Users/hp/Downloads/Cytogeneticeffectsofalbendazoleonstemcellsmicebone.pdf |
| 32 | Faruk H. Al Jawad | 2016 | Human | Toxicity | HSCs | peripheral blood | microscopic | https://doi.org/10.29409/ijcmg.v9i1.181 |
| 33 | Araz J. Mohamad | 2009 | Rat | Toxicity | MSCs | bone marrow | microscopic | https://research.amanote.com/publication/4ZX22HMBKQvf0Bhi6EJZ/effect-of-over-dose-synthetic-estradial-17---hormone-on-some-peripheral-blood-parameters |
| 34 | Rihab Nasr | 2012 | Mouse | molecular | MSCs | bone marrow | flowcytometry | https://ddl.mbrf.ae/book/8065104 |
| 35 | Intissar N. Waheed | 2011 | Human | differentiation | UCBSCs | placenta | ICC | https://www.researchgate.net/publication/346333881_Neural_Cell_Differentiation_of_Mesenchymal_Stem_Cells_Isolated_from_Human_Umbilical_Cord_Blood_In_Vitro |
| 36 | Shalal M. Hussain | 2015 | Mouse | differentiation | MSCs | bone marrow | ICC | https://anjs.edu.iq/index.php/anjs/article/view/294/240 |
| 37 | Abdulmajeed A. Homadi | 2017 | Human | transplantation | HSCs | bone marrow | Clinical response criteria | http://ectrx.org/forms/ectrxcontentshow.php?doi id=10.6002/ect.mesot2016.P21 |
| 38 | Mahfoodha A. Umran | 2016 | Mouse | differentiation | MSCs | tissue | ICC | https://www.researchgate.net/publication/331974756_Comparative_Study_of_Expansion_and_Proliferation_of_Adult_Mice_Mesenchymal_Stem_Cells_Derived_from_Bone_Marrow_and_Adipose_Tissue |
| 39 | Ali Hasan | 2011 | Mouse | Toxicity | MSCs | bone marrow | microscopic | https://www.researchgate.net/publication/216868796 |
| 40 | Raja Kummoona | 2018 | Rabbit | treatment | MSCs | bone marrow | microscopic | https://doi.org/10.15436/2471-0598.18.1879 |
| 41 | Araz J. Mohamad | 2009 | Rat | Toxicity | MSCs | bone marrow | Cytotoxicity assay | https://research.amanote.com/publication/4ZX22HMBKQvf0Bhi6EJZ/effect-of-over-dose-synthetic-estradial-17---hormone-on-some-peripheral-blood-parameters |
| 42 | Intissar N. Waheed | 2014 | Rat | treatment | MSCs | bone marrow | IHC | https://doi.org/10.5897/AJB2014.13751 |
| 43 | Majeed A. Sabbah | 2017 | Human | molecular | HSCs | bone marrow | molecular | file:///C:/Users/hp/Downloads/ijcmgadmin,+Journal+manager,+129034.pdf |
| 44 | Mohanad Kh. Alani | 2015 | Rat | treatment | MSCs | bone marrow | IHC | http://dx.doi.org/10.1155/2015/984146 |
| 45 | M. A. Aladhami | 1977 | Fish | isolation | HSCs | embryo | microscopic | https://doi.org/10.1111/j.1440-169X.1977.00171.x |

| | Authors first name | Year | Type of organism | Type of study | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|---|---|
| 46 | Intissar N. Waheed | 2010 | Rat | differentiation | MSCs | bone marrow | ICC | https://www.researchgate.net/publication/275461815 |
| 47 | Layla Alhasan | 2015 | Rat | treatment | MSCs | bone marrow | molecular | https://doi.org/10.1039/C5IB00206K |
| 48 | Athraa Y. Alhijazi | 2015 | Rat | treatment | MSCs | bone marrow | IHC | https://www.eajournals.org/wp-content/uploads/Expression-of-BMP7-in-bone-tissue-treated-with-Aloe-Vera.pdf |
| 49 | Nasheet G. Mustafa | 2013 | Mouse | molecular study | NSCs | brain | molecular | https://www.researchgate.net/publication/275274394 |
| 50 | Baydaa H. Mutlak | 2008 | Human | differentiation | UCBSCs | placenta | ICC | https://www.researchgate.net/publication/275462281 |
| 51 | Haidar H. Alfatlawi | 2016 | Human | Markers expression | HSCs | peripheral blood | flowcytometry | DOI: 10.4103/2072-8069.198119 |
| 52 | Farooq I. Mohammad | 2012 | Human | molecular study | ESCs | embryo | molecular | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3459939/ |
| 53 | Mohammed A. Alzubaidi | 2016 | Human | molecular study | MSCs | bone marrow | molecular | https://pubmed.ncbi.nlm.nih.gov/27783707/ |
| 54 | M. H. Mohammed | 2012 | Chicken | Virus replication | MSCs | embryo | ICC | http://jwpr.science-line.com/index.php?option=com_content&view=article&id=13&Itemid=15 |
| 55 | Intissar N. Waheed | 2010 | Mouse | differentiation | ESCs | embryo | ICC | http://jjbs.hu.edu.jo/files/v4n3/final%20published%2022-8-2011.pdf |
| 56 | Entedhar K. Hussain | 2015 | Human | differentiation | UCBSCs | placenta | ICC | https://www.researchgate.net/publication/275462424 |
| 57 | Abdul-Jabbar F. A. | 2019 | Human | differentiation | NSCs | brain | ICC | http://www.mmjonweb.org/text.asp?2018/17/2/69/24611 |
| 58 | Bassim A. Jassim | 2016 | Rabbit | Histological study | ESCs | embryo | IHC | https://www.researchgate.net/publication/330738914_Histological_study_of_development_liver_in_Indigenous_Rabbits_Fetuses |
| 59 | Hana Kh. Ismail | 2020 | Mouse | Protective effect | MSCs | placenta | IHC | https://www.semanticscholar.org/paper/Protective-effect-of-placental-mesenchymal-stem-on-Ismail-Al-Sabawy/388a6e4fe9fbd9a238b8428226eb590abe9b781d |
| 60 | Hebat Alla A. Abdulla | 2018 | Human | Toxicity | UCBSCs | placenta | microscopic | https://scholar.google.com/citations?view_op=view_citation&hl=en&user=1b9zEW0AAAAJ&citation_for_view=1b9zEW0AAAAJ:7PzlFSSx8tAC |
| 61 | Maeda H. Mohammad | 2020 | Mouse | differentiation | MSCs | tissue | ICC | https://dx.doi.org/10.21123/bsj.2020.17.1(Suppl.).0235 |
| 62 | Nidal K. Alrahal | 2011 | Human | cryopreservation | PBSCs***** | bone marrow | microscopic | https://www.academia.edu/78499864/Alternative_Methods_of_Cryopreservation_of_Human_Peripheral_Blood_Stem_Cells_for_Marrow_Transplantation |
| 63 | Oday K. Luaibi | 2015 | Dog | treatment | MSCs | bone marrow | IHC | https://www.semanticscholar.org/paper/Comparative-study-between-the-effect-of-stem-cells-Luaibi/ea11bd59c52a005e66b5e3ec4894dc3ef416f49c |
| 64 | Wafaa Mohammed | 2014 | Human | transplantation | mononuclear cell | bone marrow | Clinical response criteria | file:///C:/Users/hp/Downloads/Complications_For_Bone_Marrow_Transplant.pdf |
| 65 | Zahra Altimimi | 2018 | Mouse | isolation | MSCs | Bone marrow | ICC | https://www.mendeley.com/catalogue/627fed12-7d4e-3687-92a1-04c84ea79793/ |
| 66 | Zeyad A. Shabeeb | 2018 | Human | differentiation | UCBSCs | placenta | microscopic | https://www.iasj.net/iasj?func=fulltext&aId=165193 |
| 67 | Maeda H. Mohammad | 2019 | Mouse | differentiation | MSCs | bone marrow | ICC | https://www.worldresearchersassociations.com/BiotechSpecialIssueMarch2019/42.pdf |

| | Authors first name | Year | Type of organism | Type of study | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|---|---|
| 68 | Omar A. Hamid | 2016 | Mouse | Tissue engineering | ESCs | embryo | ICC | https://www.researchgate.net/publication/307147622 |
| 69 | Abdulmajeed A. Homadi | 2019 | Human | clinical trail | mononuclear cell | bone marrow | Clinical response criteria | https://pubmed.ncbi.nlm.nih.gov/30777565/ |
| 70 | Snur M. A. Hassan | 2019 | Mouse | Markers expression | colon | tissue | IHC | https://doi.org/10.1155/2019/5134156 |
| 71 | Nawal M Abdullah | 2017 | Human | Markers expression | colon | tissue | IHC | file:///C:/Users/hp/Downloads/Immunohistochemicalexpressionofnonneoplastictumorsofcolon.pdf |
| 72 | Marta C. | 2019 | Human | transplantation | HSCs | peripheral blood | Clinical response criteria | https://pubmed.ncbi.nlm.nih.gov/30915157/ |
| 73 | Rafal H. Abdalla | 2018 | Mouse | isolation | MSCs | bone marrow | ICC | http://doi.org/10.23937/2469-570X/1410054 |
| 74 | Fadhel F. Kadhum | 2019 | Human | transplantation | mononuclear cell | bone marrow | Clinical response criteria | http://www.indianjournals.com/ijor.aspx?target=ijor:ijphrd&volume=10&issue=1&article=166 |
| 75 | Khalida I. Noal | 2019 | Human | Markers expression | Prostatic Carcinoma | tissue | IHC | https://www.researchgate.net/publication/340645736 |
| 76 | Hassan M. Abass | 2020 | Human | transplantation | PBSCs | bone marrow | Clinical response criteria | https://www.mdpi.com/2218-0532/88/1/12/pdf |
| 77 | Buthainah Alazzawi | 2020 | Human | differentiation | MSCs | bone marrow | ICC | file:///C:/Users/user/Downloads/The_Secretome_of_Mesenchymal_Stem_Cells_Prevents_I.pdf |
| 78 | Hamid H. Enezei | 2020 | Human | molecular study | Dental stem cells | Cell line | molecular | https://www.researchgate.net/publication/338954382 |
| 79 | Jean El-Cheikh | 2019 | Human | treatment | PBSCs | bone marrow | Clinical response criteria | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6349008/ |
| 80 | Hassein A. Altoban | 2018 | Human | transplantation | mononuclear cell | bone marrow | molecular | http://www.ijhonline.org/temp/IraqiJHematol8138-5520392_152003.pdf |
| 81 | Sarkawt Hamad | 2019 | Human | differentiation | hiPSC-******CMs* | tissue | molecular | https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6831300/ |
| 82 | Rasha H. Dosh | 2019 | Mouse | differentiation | Intestinal stem cells | tissue | IHC | https://pubs.rsc.org/en/content/articlelanding/2019/bm/c9bm00541b#!divAbstract |
| 83 | Ihab Ali | 2019 | Human | isolation | ***MelSCs***** | tissue | ICC | http://www.indianjournals.com/ijor.aspx?target=ijor:ijphrd&volume=10&issue=5&article=233 |
| 84 | Khalid B. Arif | 2019 | Human | Marker expression | Breast cancer | tissue | ICC | https://www.researchgate.net/profile/Khalid_Arif5 |
| 85 | Abdullatif A. Aljuboury | 2019 | Human | clinical trail | Dental stem cell | tooth | Clinical response criteria | http://www.indianjournals.com/ijor.aspx?target=ijor:ijphrd&volume=10&issue=10&article=171 |
| 86 | Abdulmajeed A. Homadi | 2019 | Human | clinical trail | mononuclear cell | bone marrow | Clinical response criteria | https://medcraveonline.com/JSRT/JSRT-05-00129.pdf |
| 87 | Ahmed M. Alshammari | 2017 | Mouse | treatment | MSCs | tissue | ICC | https://www.researchgate.net/publication/317498679 |
| 88 | Ihab N. Safi | 2019 | Rabbit | treatment | MSCs | tooth | ICC | https://www.researchgate.net/publication/335716531 |
| 89 | Rafal H. Abdalla | 2016 | Mouse | differentiation | MSCs | bone marrow | Scanning electron microscope | https://www.sciencedirect.com/science/article/abs/pii/S0891061816301326 |
| 90 | Ihab N. Safi | 2020 | Human | isolation | hPDLSCs******** | tooth | Scanning electron microscope | http://creativecommons.org/licenses/by-nc-nd/4.0/ |

| | Authors first name | Year | Type of organism | Type of study | Type of sample | Type of organ, tissue, cell | Technique | Link |
|---|---|---|---|---|---|---|---|---|
| 91 | Ghada Firas Faisal | 2019 | Human | Evaluation of the Level of Stem Cell Factor | Stem cell factors | follicular fluid stem cells | enzyme-linked immunosorbent assay. | https://www.semanticscholar.org/paper/Evaluation-of-the-Level-of-Stem-Cell-Factor-in-and-Faisal-Al-kawaz/1384938bef0b54bdaa77ddbedd8a9cbb2a1ca0eb |
| 92 | Fakhraldin Marwan Flaih | 2022 | Human | Clinical trail | Stem cell transplantation | Bone disease from Multiple Myeloma patients | Clinical response criteria | https://www.semanticscholar.org/paper/Assessment-of-Bone-Disease-in-Multiple-Myeloma-Stem-Flaih-aqabi/99df30f24b671f02b0f06c38da3ee771b9d5cb58 |
| 93 | Ahmed Kadhim Munahi | 2023 | Dog | Treatment: Regeneration of Acute Spinal Cord Injury | MSCs | Adipose tissue | IHC | https://scholar.google.com/citations?view_op=view_citation&hl=en&user=D1a3u_wAAAAJ&citation_for_view=D1a3u_wAAAAJ:mVmsd5A6BfQC |
| 94 | Nibras Hatim Khamees | 2023 | Human | differentiation | MSCs | bmMSCs******** | ICC & microscopic | https://journals.lww.com/mtmj/Fulltext/2022/21020/The_Impact_of_Media_Supplement_on_the_Viability,.12.aspx |
| 95 | Wissam Abdullah Alhayani | 2022 | Rat | treatment | MSCs | Skin wound healing | Microscopic & IHC | https://www.semanticscholar.org/paper/The-Efficacy-of-Mesenchymal-Stem-Cells-loaded-in-on-Alhayani/0a252c59bba1e47c3ca7bafd5e0a0b2565fa5d4f |
| 96 | Aqeel Kazim Mohsen | 2024 | Human | treatment | Adipose stem cells | Adipose tissue | Clinical responses | https://iasj.rdd.edu.iq/journals/uploads/2025/08/14/97efdb2b553564b7d60bbdd035d78991.pdf |
| 97 | Furqan M. Abdulelah | 2022 | Human | Case study | Stem cells transplantation | HSCs | Clinical responses | https://doi.org/10.32947/ajps.v22i4.958 |
| 98 | Abdullah, Safyia Khalid | 2023 | Human | Molecular study | Gastric Epithelial Stem Cells | Gastric disease | Gene expression | https://journals.lww.com/mtmj/fulltext/2023/22010/analysis_of_correlation_between_the_important.18.aspx |
| 99 | Ghassan Khudhair Esmae | 2024 | Mice | Histopathological study | bmMSCs | liver | IHC | https://doaj.org/article/3c8d52f984f941f593202f39dd4fcf1d |
| 100 | Maryam Abdhlkadhum | 2021 | Human | Evaluated autologous hemopoietic stem cell transplant. cohort study | Bone marrow transplantation | Bone marrow for Hodgkin disease | Clinical responses | https://journals.lww.com/ijhm/fulltext/2021/10010/the_outcome_of_relapsed_refractory_hodgkin_s.11.aspx_ |
| 101 | Alsajri , Alaa Hussein | 2022 | Human | Case report | Bone marrow transplantation | Bone marrow with Hodgkin disease | Clinical responses | https://journals.lww.com/ijhm/fulltext/2022/11020/cross_allergic_reactions_between_etoposide_and.19.aspx |
| 102 | Maeda H. Mohammad | 2023 | Mouse | isolation | NSCs** | MSCs | ICC | https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/7280 |

* MSCs: Mesenchymal stem cells
** NSCs: Neural stem cells
***UCBSCs: Umbilical cord blood stem cells
**** HSCs: Hematopoietic stem cells
***** ESCs: Embryonic stem cells
****** PBSCs: Peripheral blood stem cells
******* hiPSC-CMs: Human induced pluripotent stem cells
******** MelSCs: Melanocyte stem cells
********* hPDLSCs: periodontal ligament stem cells
********** bmMSCs: Bone marrow-derived mesenchymal stem cells

**Review articles**

The Iraqi review articles published between 2007 and 2023 included 21 articles (Table 1), 23.81% of which were review articles published in 2022, followed by 14.29% in both 2023 and 2020, as shown in Figure[3].

Most review articles address stem cells, their classification, importance and applications, hematopoietic stem cell transplantation[6], stem cells present in periodontal cells[7], and follicular vitiligo [8].

Additionally, many review articles discuss the therapeutic characteristics of stem cells[9, 10, 11, 12] discusses the role of stem cells in cancer therapy. Another study [13] described cancer stem cells as the dark side of stem cells. Finally, in a very interesting review, 2014[14] presented the necessary laws and legal conditions to extract stem cells from the human body and use them in treatment or transplantation.

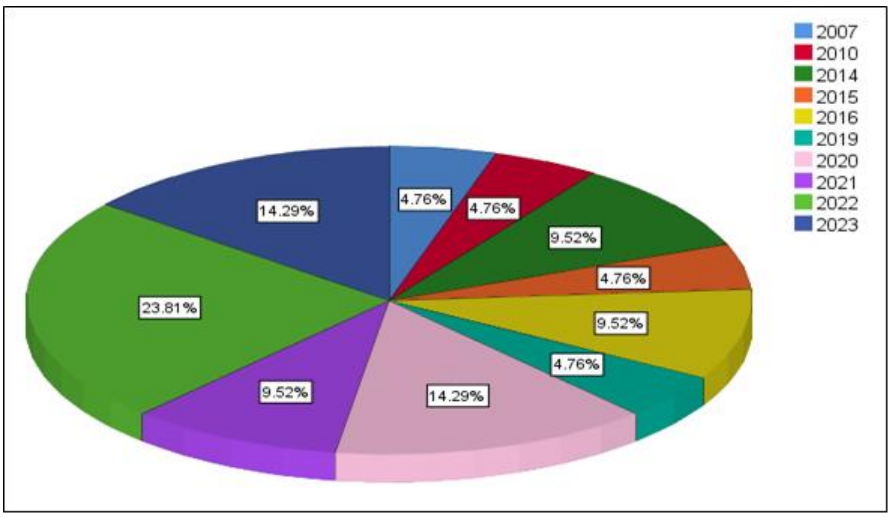


Figure 3. Stem cell publication years of the review studies included in the systematic review

**Cancer stem cell articles**

The Iraqi cancer stem cell articles published between 2008 and 2024 included 9 articles (Table 2), 33.33% of which were published in 2019, 22.22% in 2018, and 11.11% in 2008, 2014, 20017, and 2024, as shown in Figure 4.


Figure 4. The publication of years of the cancer stem cell studies included in the systematic review

All the cancer stem cell articles used human samples in their studies; most of these studies used tissue as a sample (77.78%), only one study[15] used a cell line, and one study[16] used AML as a study sample (11.1%) (Figure 5).

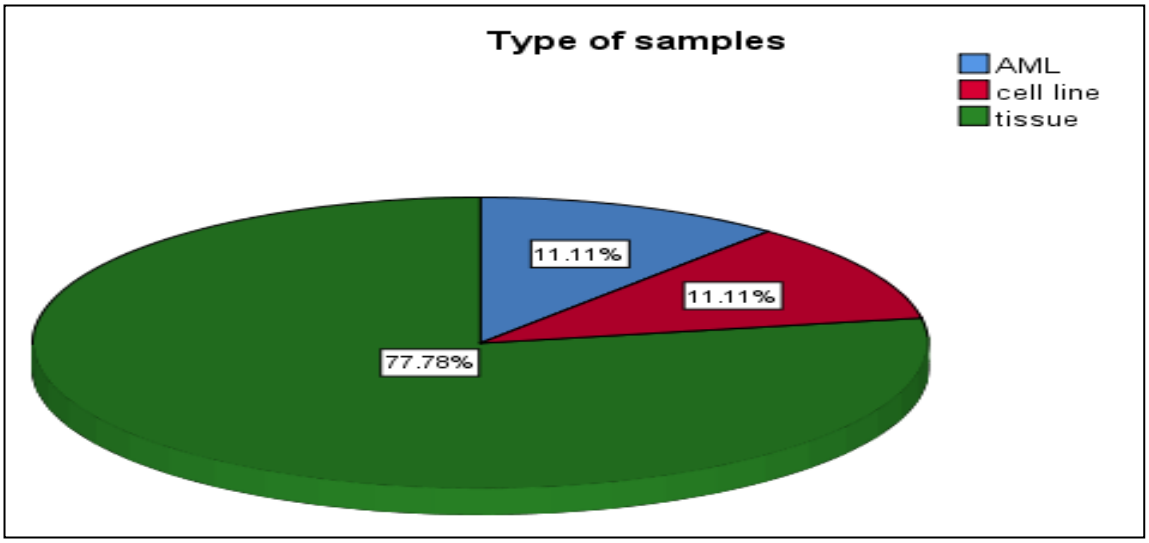


Figure 5. Types of samples of cancer stem cell studies included in the systematic review

The immunohistochemistry (IHC) technique was the most commonly used technique (66.67%), whereas 22.22% of the molecular studies and 11.11% for Immunocytochemistry (ICC) (Table 2, Figure 6).

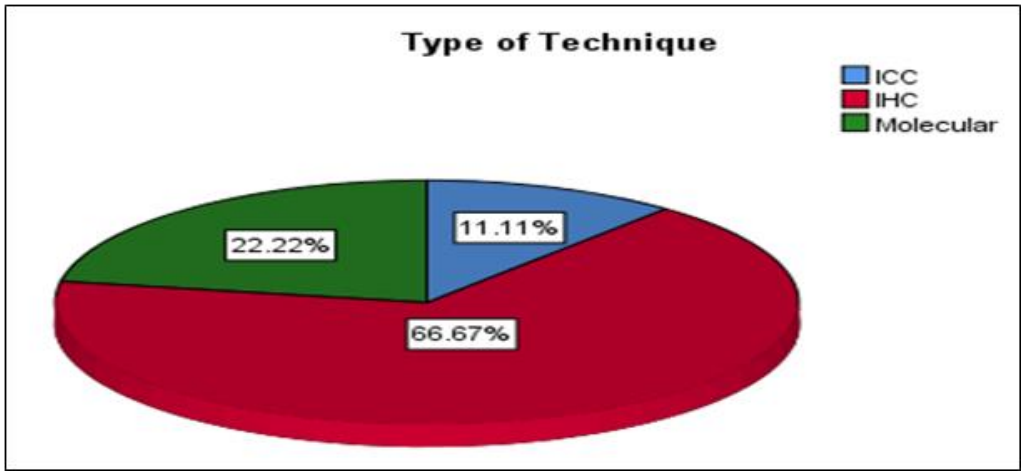


Figure 6.Types of samples in the cancer stem cell studies included in the systematic review

**Methodological studies**

The methodological Iraqi articles published between 1977 and 2024 included 102 articles (Table 3), 15.7% of which were published in 2019, 12.7% in 2016, and 8.8% in 2015, as shown in Figure (7).

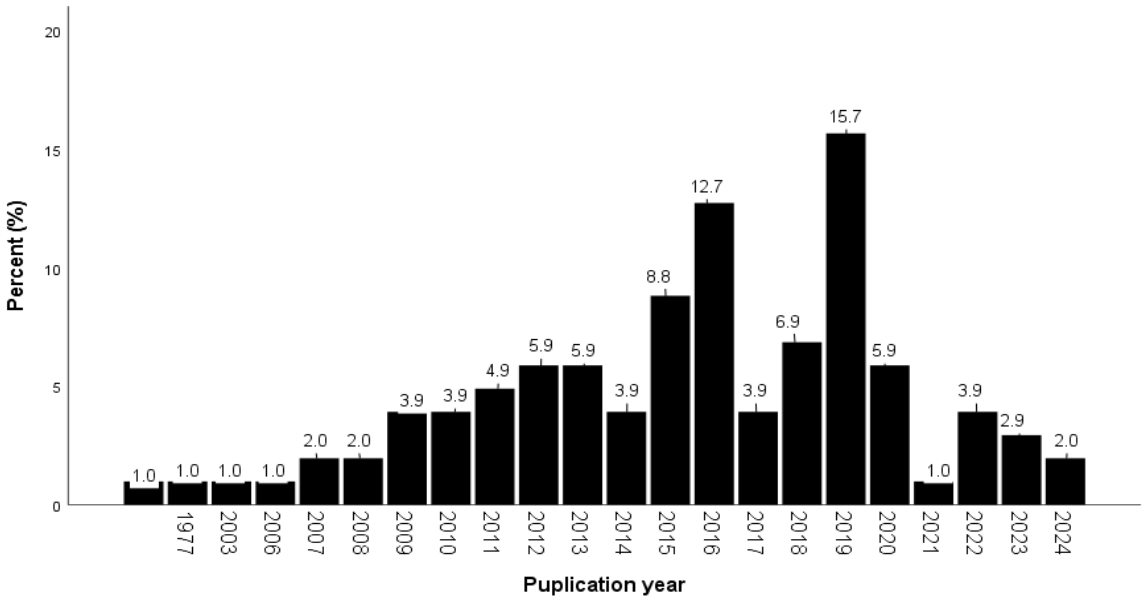


Figure 7. The percentages of publication years of methodological studies through 47 years

A high percentage of human stem cells studies (42.2%) were recorded in methodological studies, which used human samples in their studies, followed by mice (29.4%) and rats (12.7%) (Figure 8).

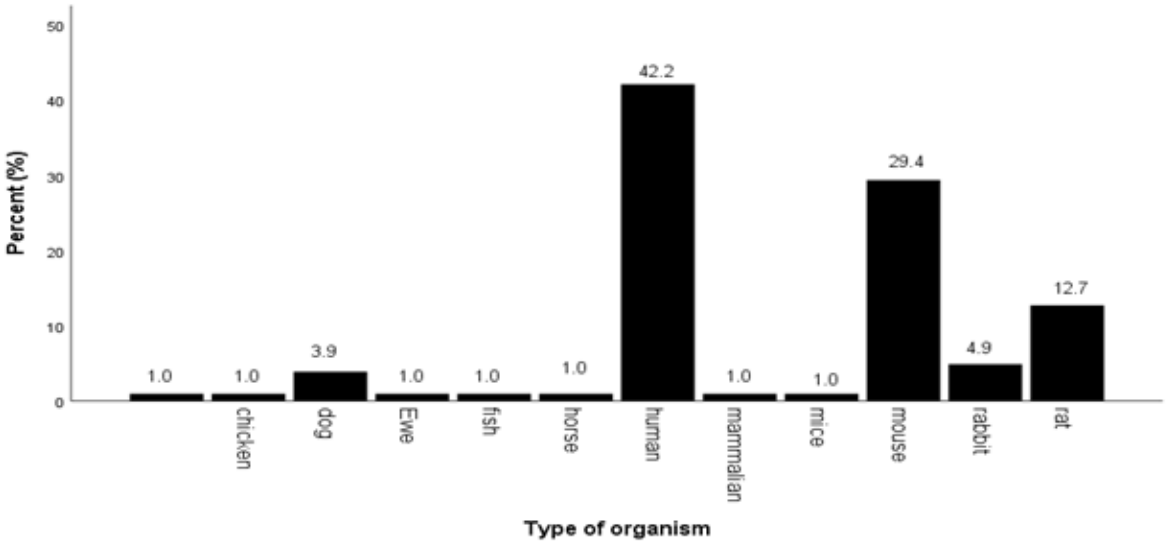


Figure 8. Percentages of different types of organisms included in the methodological studies

Differentiation studies were the highest 21.60% among other types of studies, it shows that 20.6% were treatment focus studies, and 14.7% were cells isolation focused studies (Figure 9). Most studies have used MSCs as main cells samples (48.0%), followed by hematopoietic stem cells (HSCs) and umbilical cord blood stem cells (UCBSCs), with 7.8% and 6.9%, respectively (Figure 10). The most common type of organ used was bone marrow (48.0%), as shown in Figure 11. In addition, immunocytochemistry (ICC) was the most commonly used technique (35.3%), whereas immunohistochemistry (IHC) was used for 20.6%, as shown in Figure 12.

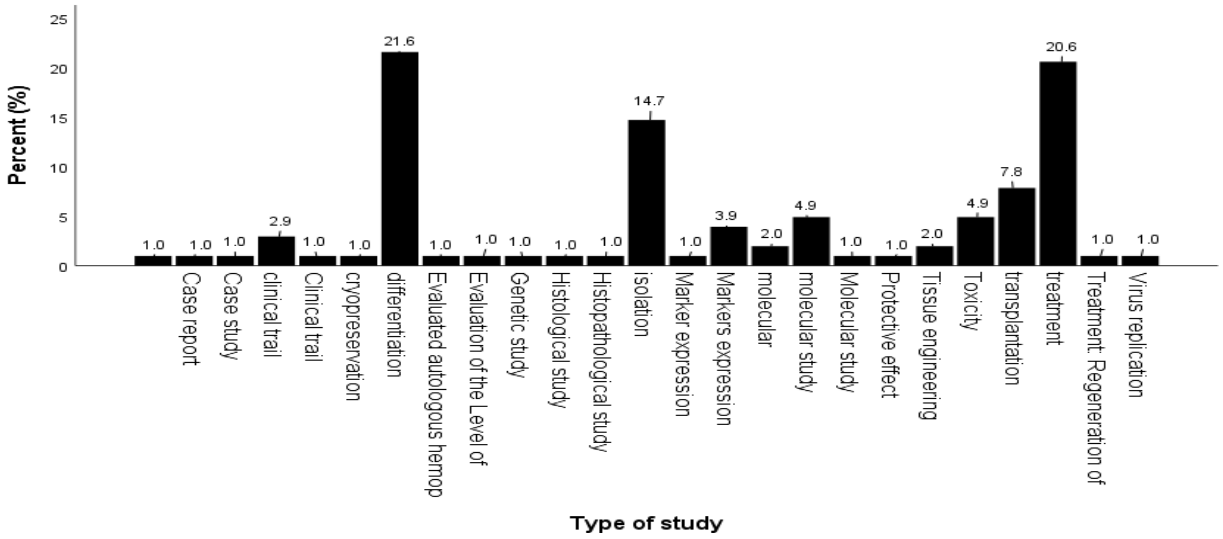


Figure 9. Percentages of different types of methodological studies

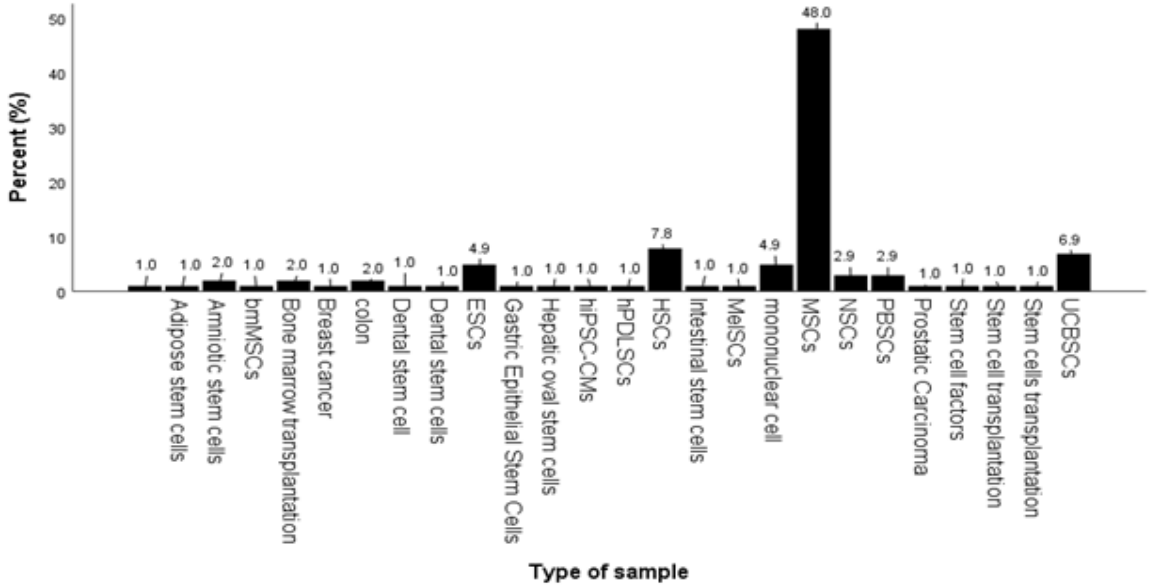


Figure 10: Percentages of different types of samples used in the methodological studies

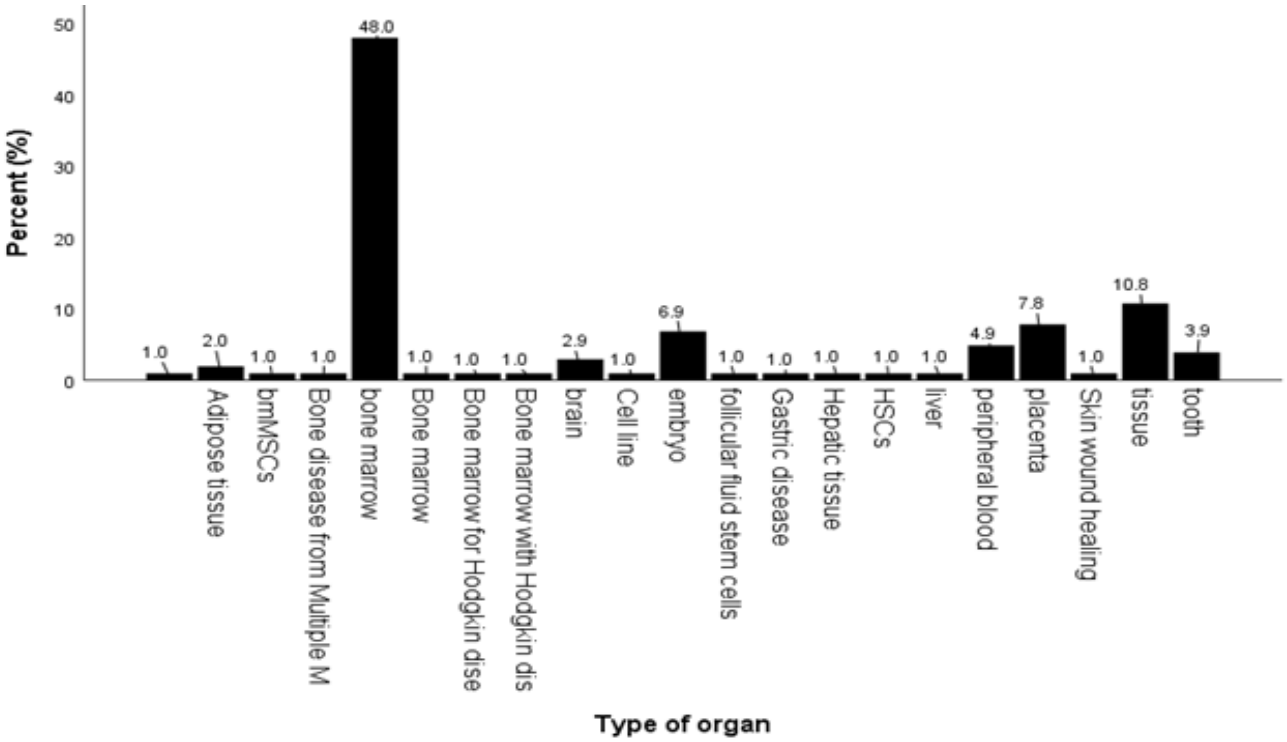


Figure 11. Percentages of different types of organs included in the methodological studies.

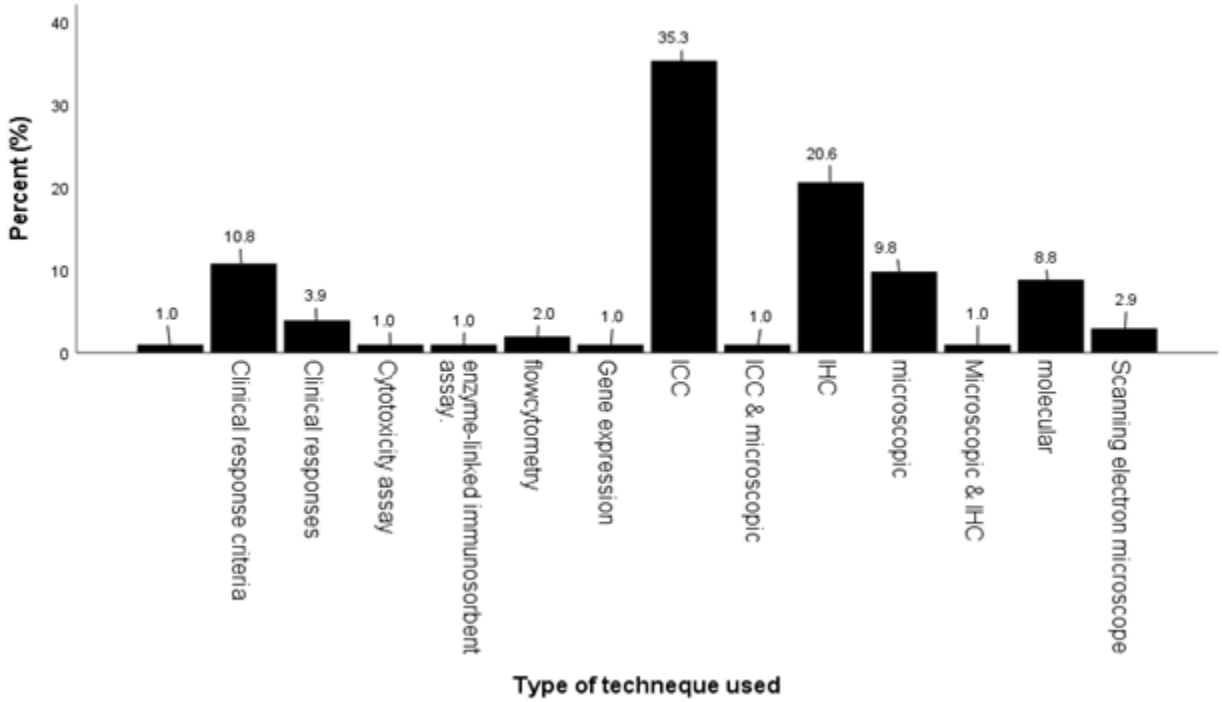


Figure 12. Percentages of different types of techniques used in methodological studies

## DISCUSSION

Despite the presence of several obstacles in Iraq, several studies in the regenerative field, especially in the stem cell field, have focused on the isolation, detection and differentiation of many types of stem cells and their use in the treatment of many diseases. All these studies were performed in Iraq and started with isolation studies; this publication started in 1977 with an experimental study of stem cell isolation and proliferation in fish[17]. Mammalian embryonic stem cells were subsequently isolated in culture[18], stem cells were isolated, and the ability of long-term culture of adult bone marrow stem cells in albino mice was studied[19].

Several studies have successfully induced the differentiation of different stem cell types and used them for treatment, such as the isolation of adult bone marrow stem cells to treat myocardial-induced infarction in albino rats [20], the isolation of MSCs and HSCs from human umbilical cord blood and the study of their neurogenic differentiation[21], and the isolation and differentiation of hepatic oval stem cells from rat hepatic tissue[22]. A study identified cancer stem cells in pediatric brain tumor gliomas[23]. Since then, the number of published stem cell studies and reviews has increased to 133 (until the first half of 2021).

Several studies have been carried out at the Iraqi Center of Cancer and Medical Genetics Research (ICCMGR) within the Stem Cell Program in the Experimental Therapy Department of ICCMGR. This project started with the isolation, detection, differentiation and treatment of many types of stem cells and started with the isolation and characterization of MSCs from human umbilical cord blood[21] and the isolation and characterization of MSCs from albino mice[25,26,27]. Several studies subsequently isolated and differentiated MSCs from mice into different cell types, including Purkinje cells[28], islets of Langerhans-like cells [29], chondrocyte cells[30,31] , motor neuron cells[32,33], neuron cells[34], neural stem cells[35,36] , and adipose stem cells[37]. Other studies have started to use stem cells for treatment, including the isolation of adipose-derived MSCs to improve the repair and regeneration of induced superficial digital flexor tendons in equine species[38], the use of HSCs from the bone marrow of ewes to evoke the immune system in immunosuppressed sheep[39], the evolution of the effect of autologous bone marrow-derived stem cells on the healing of tooth sockets in diabetic rabbits in comparison with insulin-treated and healthy control groups [40], and the production of insulin-producing cells in diabetic mice[41]. Additionally, a study produced a scaffold for use in regenerative medicine in ICCMGR[42]. This scaffold was used in the isolation of human periodontal ligament stem cells (hPDLSCs) by implanting them in fabricated polycaprolactone (PCL) for the regeneration of natural periodontal ligament (PDL) tissues[43]. Recently, work in the stem cell field has continued in the ICCMGR field through many projects.

## CONCLUSION

In the present study, we systematically reviewed all published articles on stem cells and found 146 Iraqi research studies on different methods. In conclusion, the number of studies on stem cells has increased significantly over the past twenty years, with different methods used in these studies. However, because of the small number of clinical trials for stem cell transplantation therapy, the lower frequency of patient anticipation and possible bias issues in trial designs, there is a possibility of bias. Therefore, further high quality and larger data studies are needed in the future to investigate the possibilities of stem cells in clinical settings. Additionally, further studies are needed to establish a database for Iraqi studies in different specialties.

## CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest associated with this study.

## ACKNOWLEDGMENTS

The authors would like to thank MUSTANSIRIYA UNIVERSITY (www.uomustansiriyah.edu.iq) and the Iraqi Center of Cancer and Medical Genetics Research (ICCMGR), Mustansiriyah University, Baghdad, Iraq, for their support.

**Approval by the Ethics Committee/Institution Review Board**

This work was approved by the scientific committee of the Iraqi Center of Cancer and Medical Genetics Research (ICCMGR), Mustansiriyah University, Baghdad

**Data availability statement**

The dataset created and/or analyzed during the current study will be provided if requested from the corresponding author.

**Funding statement**

This review was supported and carried out at the Experimental Therapy Department, Iraqi Center of Cancer and Medical Genetics Research (ICCMGR), Mustansiriyah University, Baghdad, Iraq.

**Ethical approval statement**

This ethical review project was approved according to the ethics of the ICCMGR scientific committee.

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